Battle Space Weather Conditions for Joint Strike Support

by
Jay Rosenthal, **Matt McGovern, and Roger Helvey**
Geophysics Branch
Naval Air Warfare Center Weapons Division
Point Mugu, California 93042

Abstract:

Battlespace meteorological and oceanographic (METOC) conditions can be defined and displayed using the Navy's C41 architecture for use in strike planning, optimizing weapons performance, and post-operation assessment. Using the Tactical Environmental Support System (TESS), METOC satellite imagery has been exploited to derive estimates of temperature and cloud conditions along Tomahawk flight paths, and integrated with operational geometry to support missile launches conducted during Joint Warrior Interoperability Demonstration (JWID)-95. The integrated displays were sent from the Battle Management Interoperability Center (BMIC) at the Naval Air Warfare Center Weapons Division at Point Mugu, and transmitted via JMCIS/SIPRNET to CINCPACFLT at Pearl Harbor, where they were inserted as strike warfare support products on a home page for transmission to other JWID participants.

TESS architecture is also being used to define cloud and other METOC conditions during support of Joint Stand-Off Weapon (JSOW) testing, during SHAREM exercises in the Arabian Gulf, and for transfer of METOC data to the Tactical Aircraft Mission Planning System (TAMPS).

Additional capability is being developed using processed visual and infrared satellite data to estimate duct height topography over low-cloud covered regions of the ocean covering thousands of square miles. In combination with overlays of large scale pressure and temperature fields, the products are also useful in relating weather map features to anticipated EM/EO propagation conditions.

1. Background:

As one of the most crucial factors in determining the outcome of warfare, weather and other METOC data describing conditions throughout the battlespace need to be quickly transmitted and understood by the warrior and mission planner. Although current efforts are underway to exploit METOC data in a PC environment, considerable capability exists now within the present C41 architecture to provide automated data directly to the warfighter. As an integral part of the Joint Maritime Command Information System (JMCIS), the Navy's Tactical Environmental Support System (TESS) can transmit digital grid and satellite data via SIPRNET from its TESS Remote Workstation (TRWS) to another TRWS-equipped platform anywhere afloat. By combining satellite imagery and extracted digital data on one display, some simple but highly informational products can be provided to describe METOC conditions throughout the battlespace in time for use as real-time or planning products. Some of this capability is both being developed and demonstrated in the Battle Management Interoperability Center (B MIC) located at the Naval Air Warfare Center Weapons Division (NAWCWPNS), Point Mugu, California. Under the sponsorship of the Space and Naval Warfare Systems Command METOC Systems Program Office (PMW-185), these capabilities are being developed, demonstrated, validated and transitioned to operational products.

2. Joint Strike Weapons Support:

During the test and evaluation of the Joint Stand-Off Weapon (JSOW) at both the China Lake Land Range and Point Mugu Sea Range, Geophysics Branch personnel exploited the TESS capabilities to ready the JSOW planning process for eventual operational use of METOC data. Since wind is a critical parameter for this glide weapon, gridded winds from the Navy's Operational Regional Atmospheric Prediction System (NORAPS) were received from the Fleet Numerical METOC Center (FNMOC) in Monterey at several levels and displayed over a grid of the Southern California operation area (figure 1). This enabled consideration of the inherent resolution and representativeness of the model output.

Since cloud occurrence, height and temperature will also be important for subsequent variants of JSOW, METOC satellite imagery has been used to demonstrate the ability to diagnose these conditions at launch, enroute, and target areas. A valuable and easy to interpret display was developed on the TRWS by combining a visual TIROS satellite image showing cloud conditions and specific geographical features over the operational area of interest, as shown in figure 2. Superimposed were isotherms of surface temperature derived from the TESS data base for as close to operation time as possible. Last, but not least, an overlay of the planned/actual missile flight path was developed so that the environmental weather conditions displayed on the screen could be specifically related to the actual coordinates and location of the missile path. By implementing this relatively easy to produce product on the TRWS, the display can then be relayed via the JMCIS system to any other participant in the operation for use in planning or performance assessment.

3. Mission and Strike Planning:

To effectively exploit METOC data for use in mission or strike planning, it is necessary to define weather conditions throughout the battlespace in real-time or for short periods in advance, and be able to provide the product to the warfighter in a quick and easy-to-understand form. Although the architecture is still evolving, several aspects of this requirement can be demonstrated and utilized today using the current configurations of TESS.

As was shown above for JSOW support, similar satellite-based capabilities were demonstrated for strike planning by NAWCWPNS in support of JWID-95. In this scenario, a Tomahawk missile was launched from the Sea Range to a target at Fallen, Nevada. As was done for real missions during Desert Storm, METOC satellite data was used to estimate temperatures along the flight path, only this time, the process was largely automated through TESS and displayed on the TRWS along the planned missile flight path. In addition, visual cloud conditions, geographic features and operational information were also displayed on the single product, so that the integrated effects of the METOC environment could be quickly assessed over each segment of the planned operation. This is shown in figure 3.

To demonstrate the ability to put these capabilities in the hands of the user, strike warfare products were transmitted via SIPRNET in BMIC to CINCPACFLT at Pearl Harbor where they were installed on the JWID METOC Home Page. The menus and product listings were then posted as shown in figures 4 and 5 where they could be accessed by other JWID participants. In addition, Geophysics personnel were able to successfully demonstrate sending strike planning products directly to the Tomahawk shooter.

In order to provide short-term forecasts of cloud cover in a form readily useable by the warrior, NAWCWPNS, under SPAWAR sponsorship, collaborated with the Naval Research Laboratory (NRL) in Monterey and NRaD in San Diego to implement the Nagle Cloud Advection Model (NCAM) which essentially provides forecast ‘satellite’ images based on sound physical and meteorological processes. NCAM has been implemented on the TESS Maxion computer as well as on a TAC-3 computer. An early form of the capability was successfully demonstrated during a recent SHAREM exercise at the Naval European METOC Center at Rota, Spain.

Successful tactical exploitation of METOC satellite data will also necessarily require the use of geostationary imagery so that changes in cloud/storm conditions can be quickly detected and animated. NAWCWPNS has been performing test and evaluation of a geostationary satellite display system and has successfully demonstrated the ability to animate several images in a time-sequence (similar to satellite 'loops' available on television) and transmit the images from the TRWS to Rota and to San Diego. Although a great deal of development remains to combine these functionalities into other existing satellite display systems, the crucial capability of providing high-resolution geostationary satellite imagery to a TRWS-equipped platform anywhere afloat has been demonstrated for the first time without the need for special satellite-receiving antennaes onboard.

Another mission planning application of METOC data is also being tested and evaluated in BMIC at NAWCWPNS. The Tactical Aircraft Mission Planning System (TAMPS) will be the provider of METOC data and products to a variety of mission planning and weapons support activities. With the assistance of personnel from NRaD and SPAWAR, the ability to transfer METOC data from TESS and TRWS to TAMPS, long a goal of NAVAIR and SPAWAR, has been recently demonstrated at Point Mugu. Gridded data and horizontal weather depictions were successfully sent from BMIC to the Central Data Base Server (CDBS) from where TAMPS was able to access the data. After some planned updates in hardware and configuration, the ability to send a variety of products from TESS to TAMPS should be feasible.

4. EM/EO Propagation Environment

To characterize the EM/EO propagation environment over broad sub-tropical ocean regions, capabilities are being developed to automatically translate satellite-derived estimates of cloud-top temperatures into estimates of elevated duct height. Termed the "Satellite IR-duct" technique, the capability provides a description of how the propagation environment varies in the horizontal. As shown in figure 6, duct height estimates can then be displayed atop satellite imagery (either visual or IR), and overlayed with synoptic scale analyses of pressure, height and temperature fields to improve the understanding and predictability of how weather systems influence propagation conditions. The **satellite-IR** duct technique requires clouds in inversion-dominated weather regimes. A complementary technique under development by the Naval Postgraduate School allows duct height estimates from satellite data in cloud-free regions. An independent method of estimating duct height over either cloudy or clear conditions has been developed from gridded data by Roger Helvey. Termed the "Equivalent Altitude", results from this method are displayed in figure 7 for approximately the same time as shown in figure **6.**

5. Summary:

The process of exploiting satellite and other METOC data for real-time weapons support and mission/strike planning has been demonstrated at Point Mugu in a much more automated fashion than has been previously used operationally. Even as the architecture migrates to a more PC environment, the critical elements of combining satellite-derived depictions of cloud cover, temperature, duct height geographical and operational data and other important environmental information, and sending simple and useful displays via **JMCIS** and standard communication links to the warrior has been demonstrated.

6. References:

(1) McGovern, M., J. Rosenthal and R. Nagy, "Summary of TESS(3) **METOC** Support for **JWID-95** from the **BMIC**", Geophysics Technical Note No. 193, NAWCWPNS, Point **Mugu,** 1995

(2) McGovern, M., "Tactical Environmental Support System (TESS(3) Semi-Automated Procedures for Displaying and Exploiting Satellite-Derived Land Temperatures Along Missile Flight Paths", Geophysics Technical Note No. 198, NAWCWPNS, Point Mugu, Nov 1996

(3) Greiman, P., J. Rosenthal and R. A. Helvey, "Synoptic Variability . Revealed by Satellite and Equivalent Altitude", paper No. 40, NATO AGARD Conference on Remote Sensing, AGARD-CP-582, Ott 1996

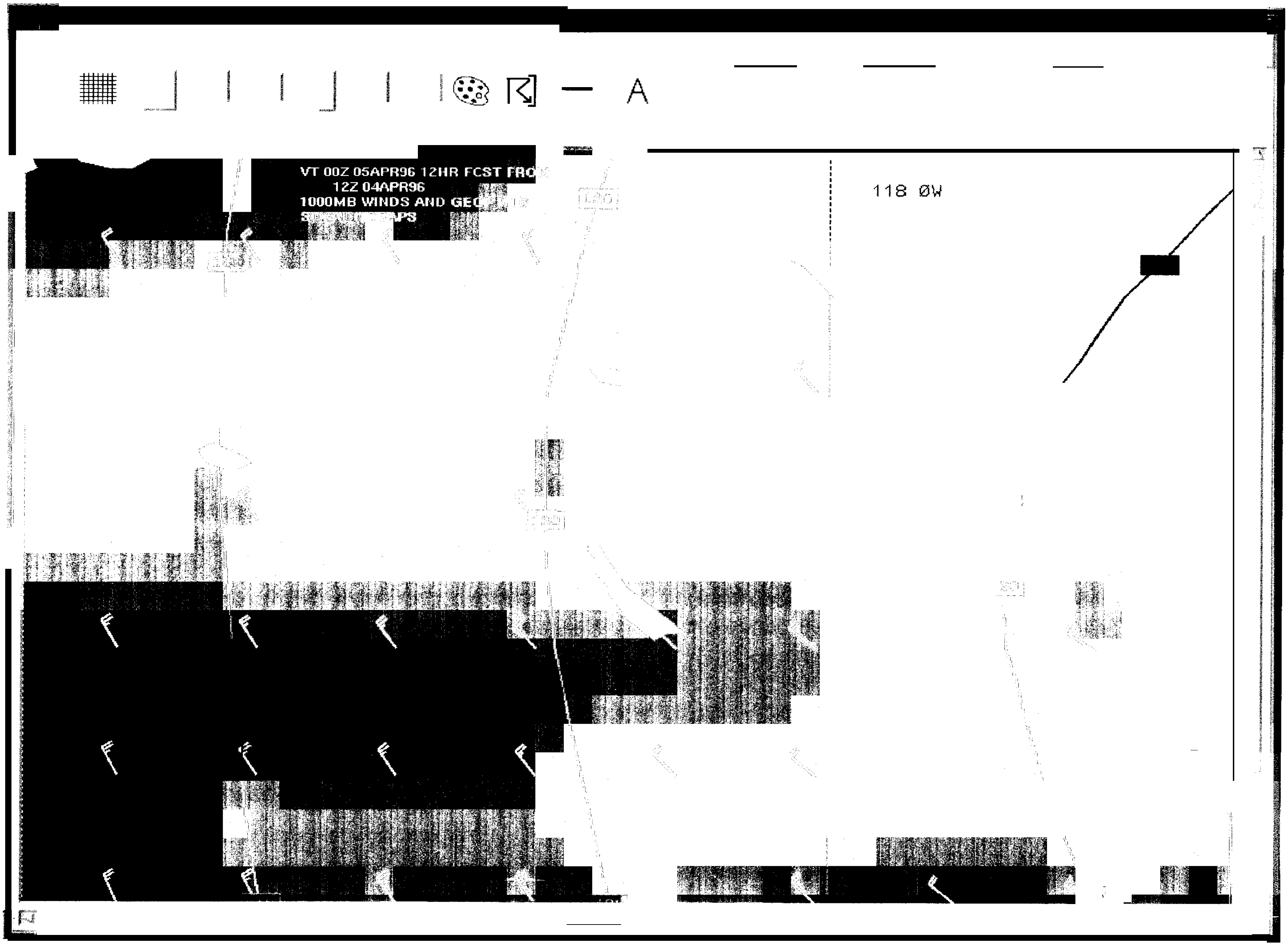

Figure 1. TESS-provided high resolution wind field for JSOW T&E

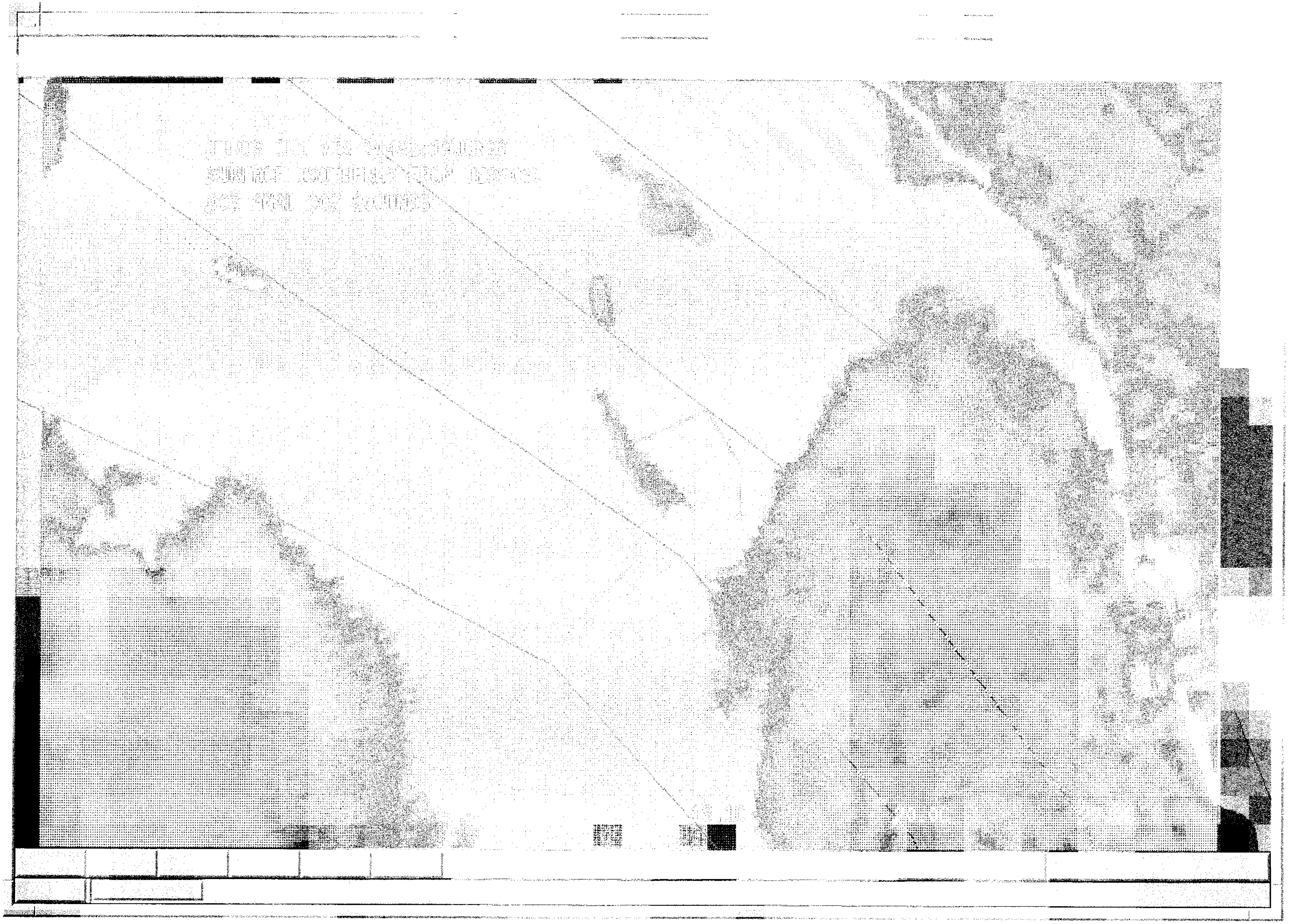

Figure 2. TRWS satellite product for JSOW combining cloud cover, temperature and operational geometry

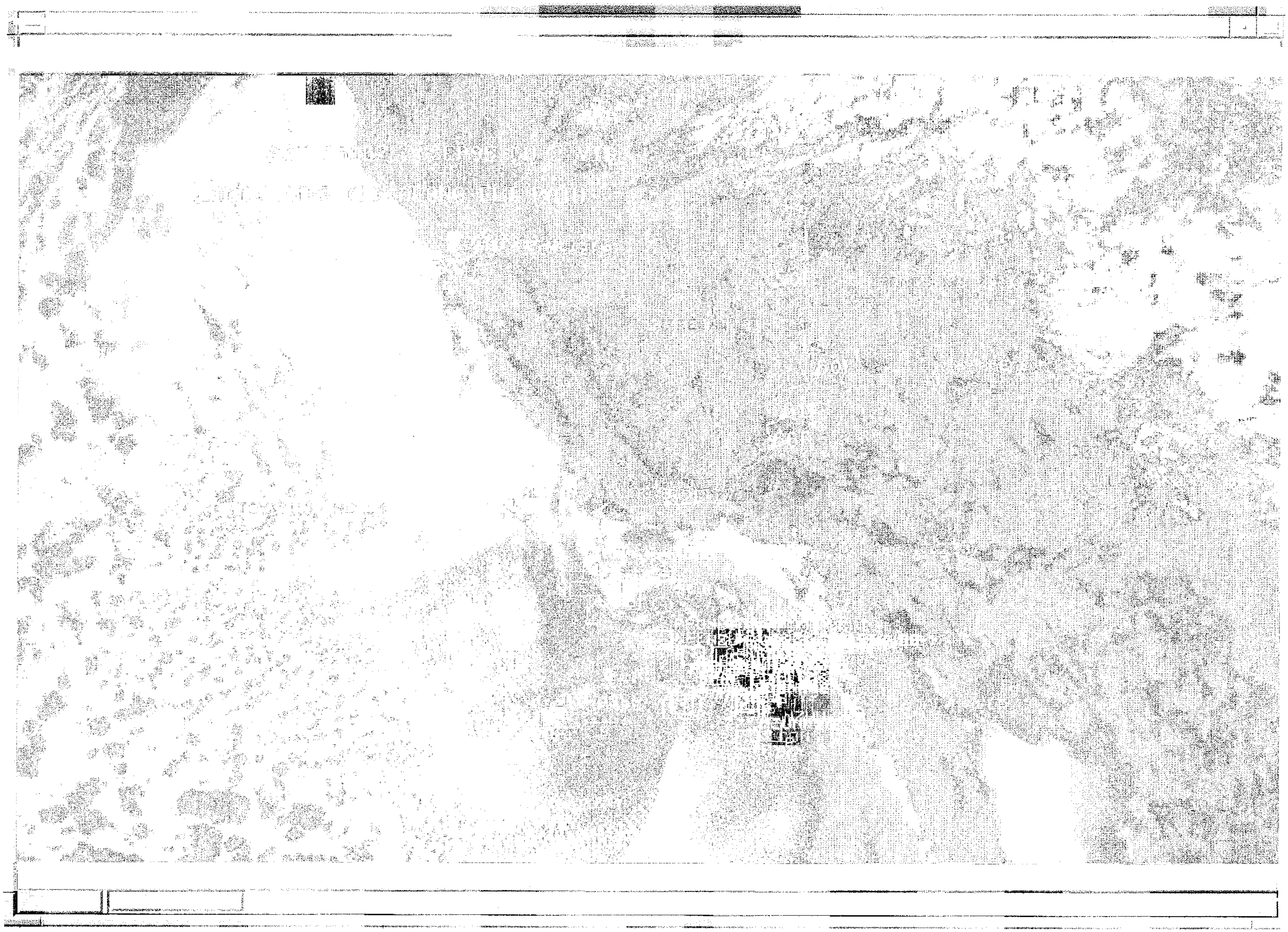

Figure 3. JWID-95 strike warfare support product combining cloud cover, Tomahawk flight path geometry and temperature along path

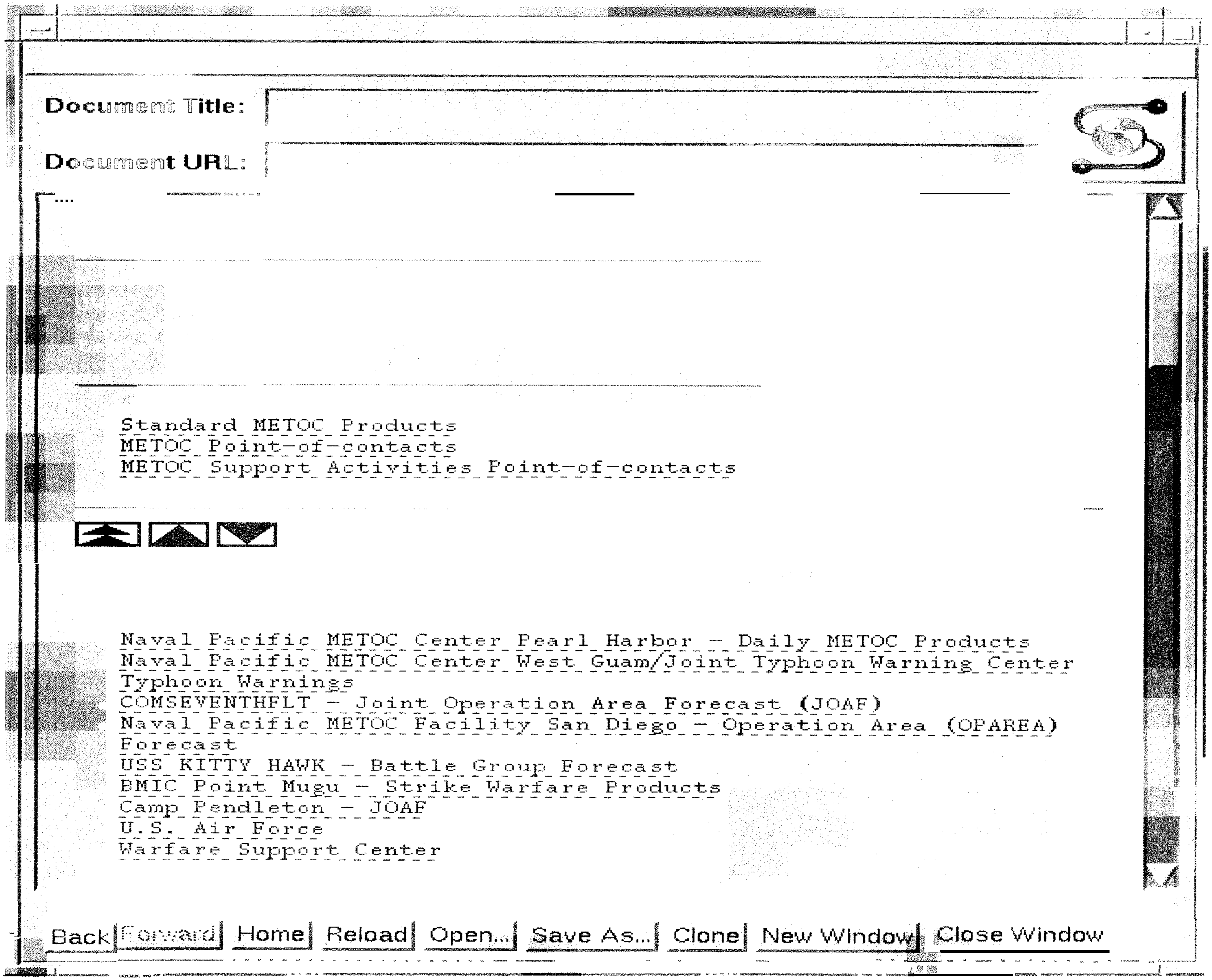

Figure 4. JWID-95 CINCPACFLT METOC Home Page product sources

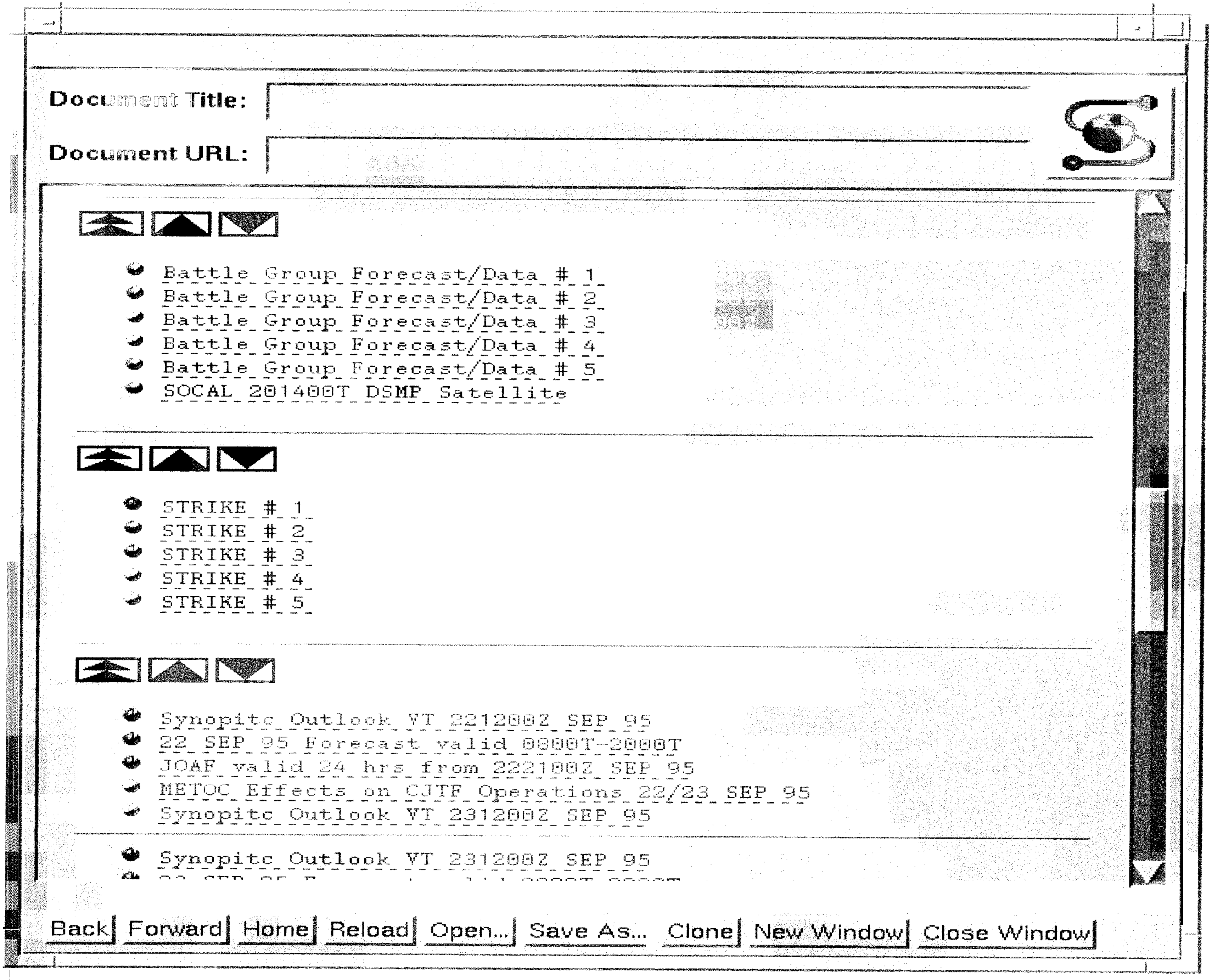

Figure 5. JWID-95 CINCPACFLT METOC Home Page product listings

Figure 7. Duct height estimates from Equivalent Altitude technique superimposed on satellite IR and atmospheric stability.